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Risks of dry spell occurrence at critical growth stages and their impacts on cotton (*Gossypium hirsutum L.*) development in production areas of Côte d'Ivoire

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Abstract

In Côte d'Ivoire, climate change is increasing the frequency of dry spells, thereby threatening cotton production, which is highly dependent on rainfall. This study analyzes the probability of dry spells lasting more than 10 days during the different growth stages of cotton in Ivorian cotton production areas. Results show that after sowing, dry spell probabilities are moderate in the North (<35%), but high in the Center (up to 63%) and the South (up to 67%). During the flowering stage, risks remain low in the North (≤20%) but reach 70% in the Center and 94% in the South. At the boll opening stage, conditions are generally favorable, with dry spell occurrence probabilities ranging between 50% and 97%. This spatio-temporal variability in dry spells highlights the need to adjust sowing dates based on seasonal forecasts and to promote drought-tolerant varieties, along with soil-water conservation practices.

Keywords: Climate risk; Dry spells; Cotton; Côte d'Ivoire

1. Introduction

Climate disruptions are among the main challenges facing countries worldwide, with particularly severe impacts in West Africa, notably in Côte d'Ivoire, where the economy remains highly dependent on agriculture. These disruptions are especially evident in changes in rainfall patterns and reductions in annual rainfall totals [1, 2]. Agriculture, a key driver of Côte d'Ivoire's economy and development, is predominantly rainfed. As a result, it remains one of the sectors most vulnerable to climate disturbances. Indeed, the success of an agricultural season, whether for annual or perennial crops, depends on the total rainfall received during the year, the timing of rainfall onset, its distribution throughout the growing season, and any interruptions during the vegetative phase or delays at harvest [3].

As in other agricultural areas in the country, where climatic conditions determine the most suitable crops, these climate variations pose a real threat to cotton production in Côte d'Ivoire [4, 5]. Indeed, climate degradation, marked by the increasing frequency of dry spells during the crop growth cycle, particularly during the flowering stage, poses numerous problems for cotton cultivation. Dry spells are defined as periods of varying length without rainfall occurring during the rainy season. They therefore correspond to abnormal or prolonged interruptions of rainfall, which can lead to water deficits for the plants [6]. These dry spells result in reduced yields, disruptions in sowing dates relative to the cropping calendar, seed loss, and, in some cases, abandonment of cotton cultivation in favor of other crops [7, 8]. When dry spells coincide with sensitive stages of crop development, such as flowering or fruiting, they can severely disrupt plant growth

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and reduce agricultural yields. For example, in Côte d'Ivoire, the 2015/2016 season recorded an unprecedented average yield of 772 kg·ha^{-1}, likely linked to climatic disturbances (deficits at the sowing and boll-formation stages), which may have influenced yields [9]. Thus, the impact of climatic dynamics on cotton cultivation may also be explained by the increasing difficulty in anticipating dry spells, further complicating the planning of sowing dates [10].

Considering these observations, it is essential to characterize the risks associated with the occurrence of dry spells across the cotton growth cycle in Côte d'Ivoire's production areas.

2. Materials and methods

2.1. Study area

The Ivorian cotton basin is located between 5°75′ and 10°75′ North latitude and between 3°5′ and 8°5′ West longitude. According to the new administrative division of Côte d'Ivoire, this area extends across six administrative districts: Denguelé, Woroba, Sassandra-Marahoué, Savanes, Vallée du Bandama, and Yamoussoukro [11]. Twelve localities were selected for this study. These sites represent the main agroclimatic conditions of the cotton production areas in Côte d'Ivoire (Figure 1).

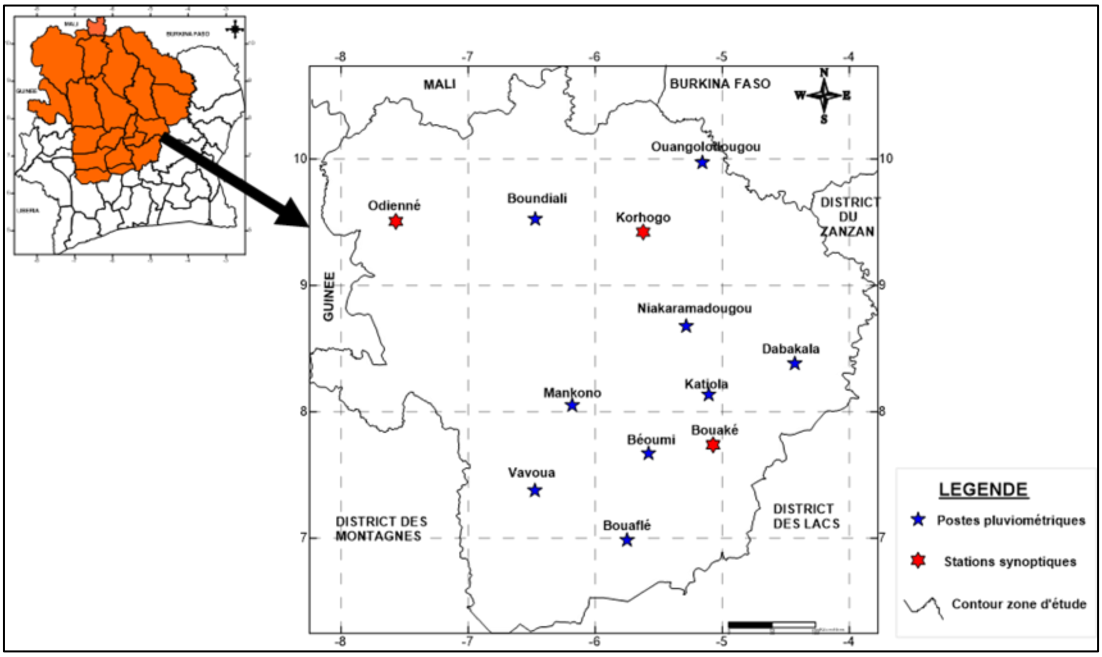

Figure 1 Cotton production area in Côte d'Ivoire

2.2. Data analysis

In West Africa, and particularly in Côte d'Ivoire, most rainfall disturbances have been observed since the 1970s [12]. Therefore, this study is based on data collected from 1971 to 2016, which also corresponds to the common time series available for the twelve selected meteorological stations. These data were reviewed and validated by *SODEXAM* and supplemented with data from the Central Laboratory for Soils, Water, and Plants (*LCSEP*) of the National Center for Agronomic Research (*CNRA*).

The plant material used in this study is cotton (*Gossypium hirsutum*). In Côte d'Ivoire, the cotton varieties currently disseminated were developed by the *CNRA*. These are generally conventional white-fiber varieties of medium length. The development cycle, from germination to the opening of the first bolls, lasts on average 120 days.

Plant responses to water stress depend on their physiological capacity to withstand both the intensity and duration of the stress, as well as on the developmental stage at which the stress occurs. Therefore, for the nine potential sowing dekads identified (from the first dekad of May to the third dekad of July), the maximum dry spells and the probabilities of occurrence of those longer than 10 days were determined and analyzed for each cotton growth stage using Instat+ V.3 037. This software is a statistical tool for agro-climatological data analysis and functions as an agro-meteorological simulation model [13].

3. Results

3.1. Occurrence of dry spells after sowing

Prolonged dry spells after sowing expose farmers to an increased risk of replanting. The sowing periods associated with high probabilities of dry spell occurrence vary across the different areas of the cotton basin.

In the Northern zone, the probabilities of dry spells longer than 10 days after sowing are below 35% and vary depending on the sowing dekad and locality (Figure 2). In the Central zone, the probabilities of dry spells exceeding 10 days after sowing are less than or equal to 30% from the first dekad of May to the first dekad of June, except for the first dekad of May in Mankono, where it reaches 42%. For the other dekads, probabilities increase, ranging from 36% to 63% across all studied localities (Figure 3). In the Southern zone, the probabilities of dry spells longer than 10 days range from 13% to 33% from the first dekad of May to the second dekad of June in the localities of Bouaflé and Bouaké. Beyond these dekads, probabilities vary between 40% and 67%. In Béoumi, probabilities remain below 35% only during the May dekads and range from 27% to 45% during the remaining dekads. In Vavoua, only the third dekad of May records a dry spell probability of 30% (Figure 4).

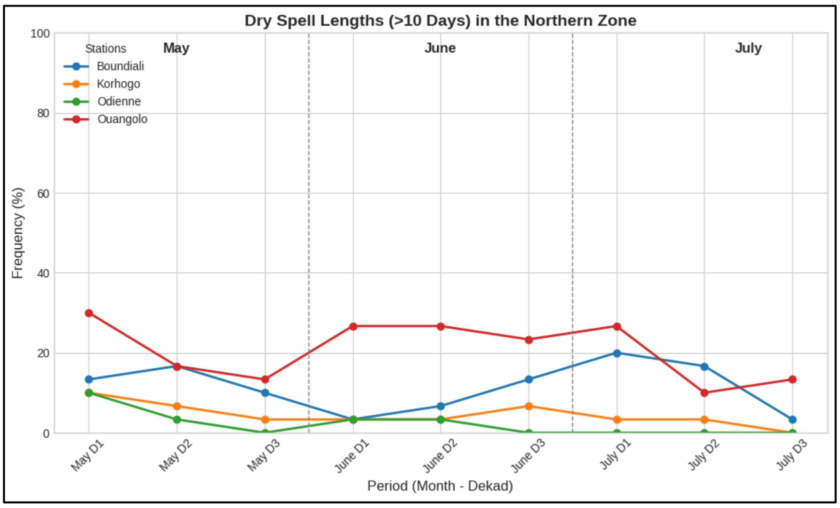

Figure 2 Probability of occurrence of dry spells longer than 10 days, after sowing (Northern zone)

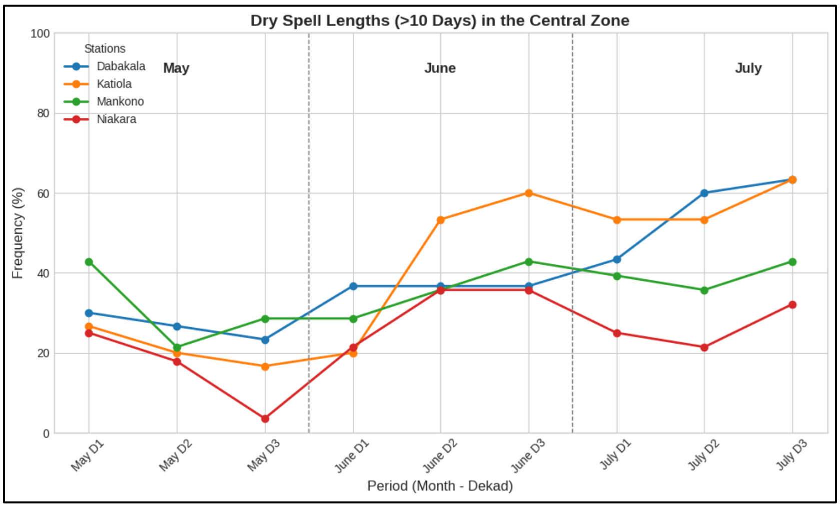

Figure 3 Probability of occurrence of dry spells longer than 10 days, after sowing (Central zone)

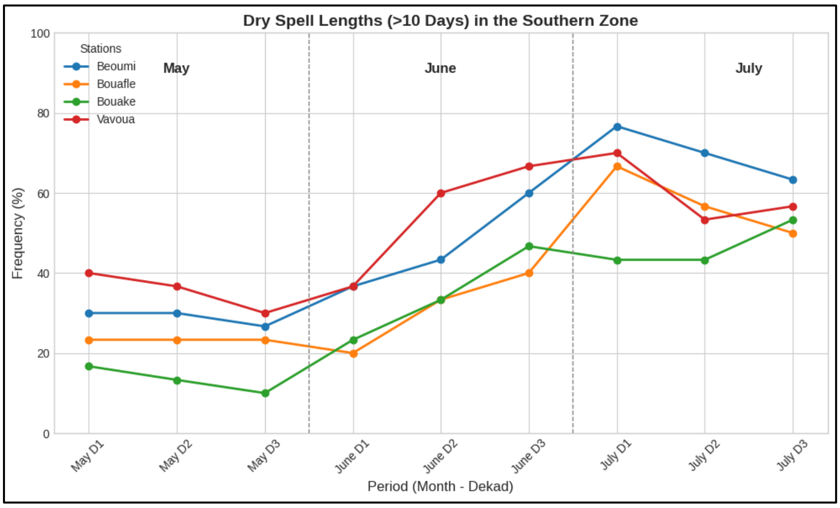

Figure 4 Probability of occurrence of dry spells longer than 10 days, after sowing (Southern zone)

3.2. Occurrence of dry spells during flowering

Water availability during the flowering phase, which lasts approximately 50 days, is one of the main factors influencing crop yield. Accordingly, for each sowing dekad, the risk of dry spell occurrence was analyzed.

In the Northern zone, the probabilities of dry spells longer than 10 days are generally low across the different sowing dekads. They range from 0% to 20% in Boundiali and Korhogo. In Odienné, except for the last two dekads of July, the probabilities of dry spell occurrence are nearly zero. In Ouangolodougou, low probabilities are observed from the second dekad of May to the second dekad of July (Figure 5). In the Central zone, at Dabakala, Katiola, and Mankono, the probabilities of dry spells longer than 10 days range from 36% to 70% for sowings carried out between the first dekad of May and the second dekad of June, as well as for sowings in the third dekad of July. In contrast, for sowings conducted between the third dekad of June and the second dekad of July, probabilities are relatively low, ranging from 14% to 33%. At Niakaramadougou, probabilities are high for the first two sowing dekads of May, at 46% and 39%, respectively. They gradually decrease to below 20% between the second dekad of June and the second dekad of July, then rise again in the third dekad of July to reach 61% (Figure 6). In the Southern zone, the probabilities of dry spells longer than 10 days range from 43% to 94% for sowings carried out between the first dekad of May and the second dekad of June. They gradually decrease to below 35% for sowings conducted between the third dekad of June and the second dekad of July, then increase again for sowings in the third dekad of July, exceeding 40% (Figure 7).

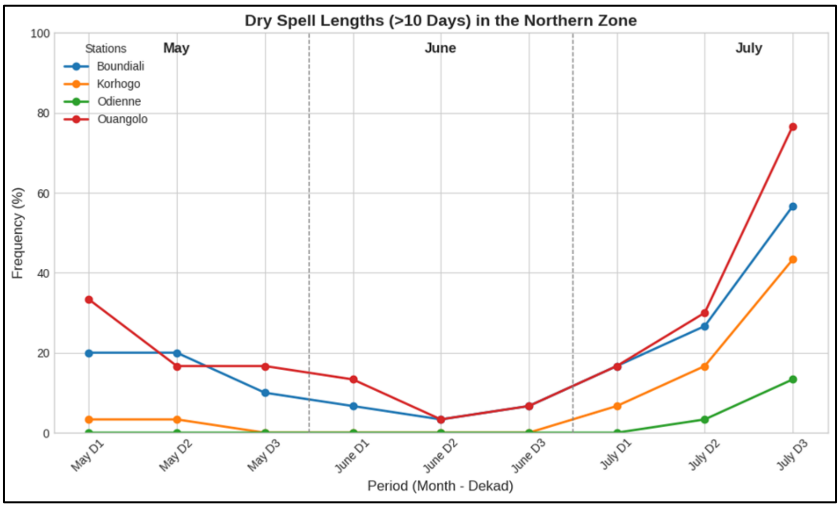

Figure 5 Probability of occurrence of dry spells longer than 10 days during the flowering stage (Northern zone)

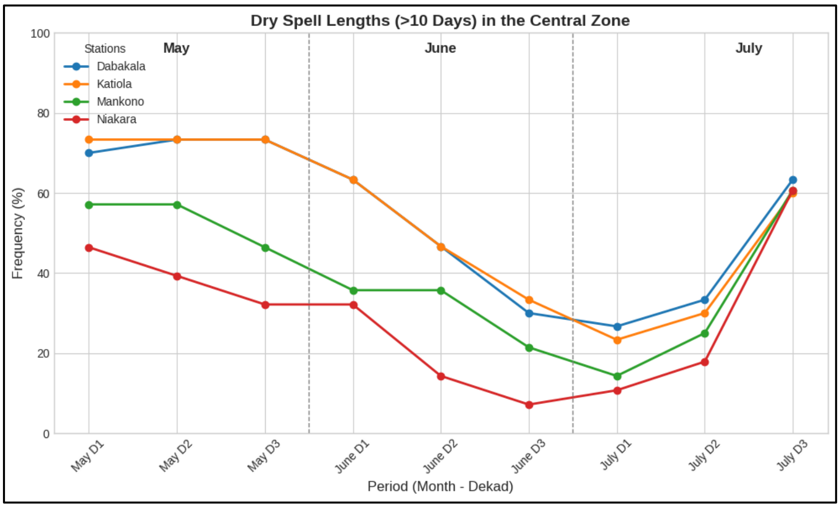

Figure 6 Probability of occurrence of dry spells longer than 10 days during the flowering stage (Central zone)

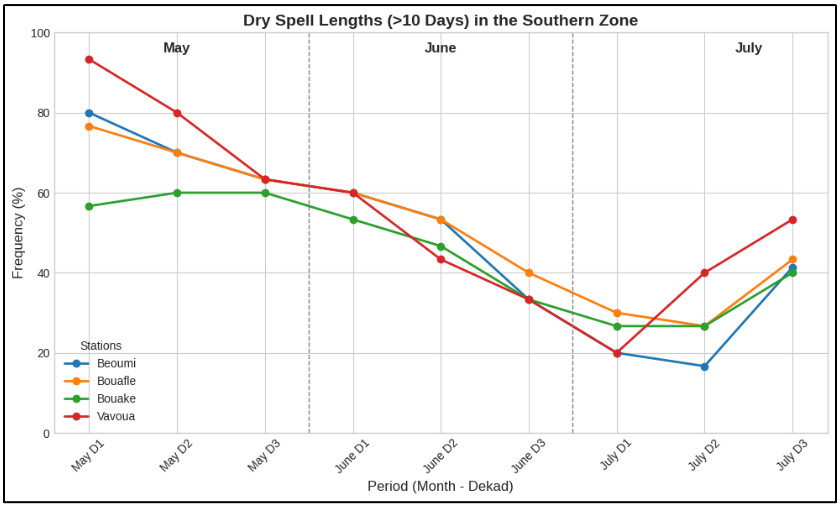

Figure 7 Probability of occurrence of dry spells longer than 10 days during the flowering stage (Southern zone)

3.3. Occurrence of dry spells at boll opening

After the opening of the mature boll, the cotton lint becomes exposed. Harvesting can begin one week after boll opening, but it is preferable to wait at least 20 days. During this period, heavy rains can negatively affect cotton quality, so dry conditions are essential at this stage.

In the Northern zone, at boll opening, the highest probabilities of dry spells for longer than 10 days are observed for sowings carried out from the second dekad of June in Ouangolodougou and from the third dekad of June in the other localities. Probabilities can reach up to 97% (Figure 8). In the Central zone, the highest probabilities of dry spells exceeding 10 days are observed for sowings conducted after the first dekad of June, with probabilities reaching up to 97% (Figure 9). In the Southern zone, at boll opening, the probabilities of dry spells longer than 10 days range between 50% and 87% from the third dekad of June to the third dekad of July across all localities (Figure 10).

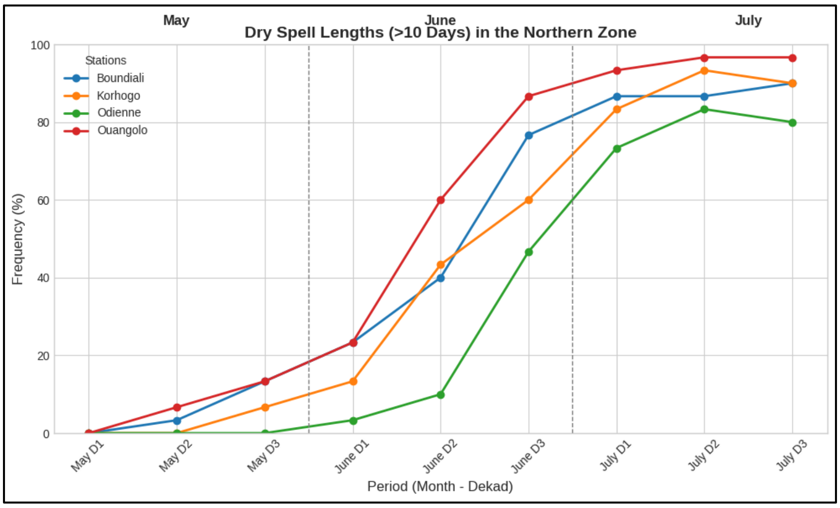

Figure 8 Probability of occurrence of dry spells longer than 10 days during the boll-opening stage (Northern zone)

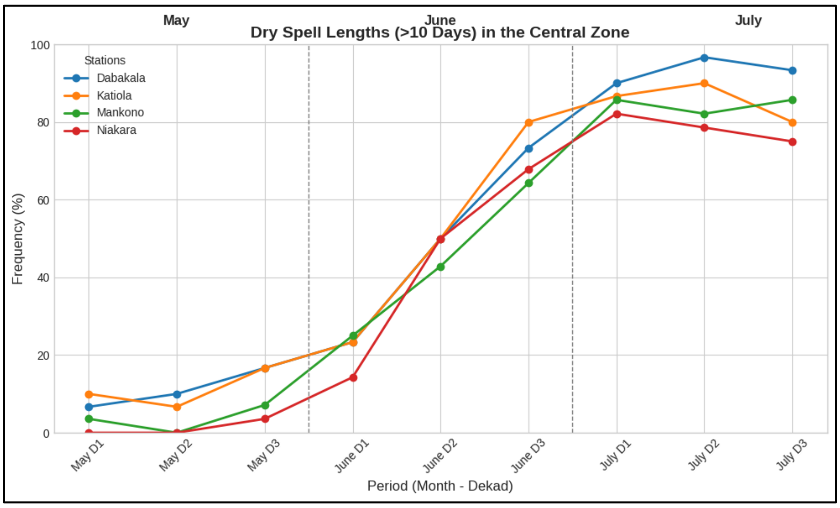

Figure 9 Probability of occurrence of dry spells longer than 10 days during the boll-opening stage (Central zone)

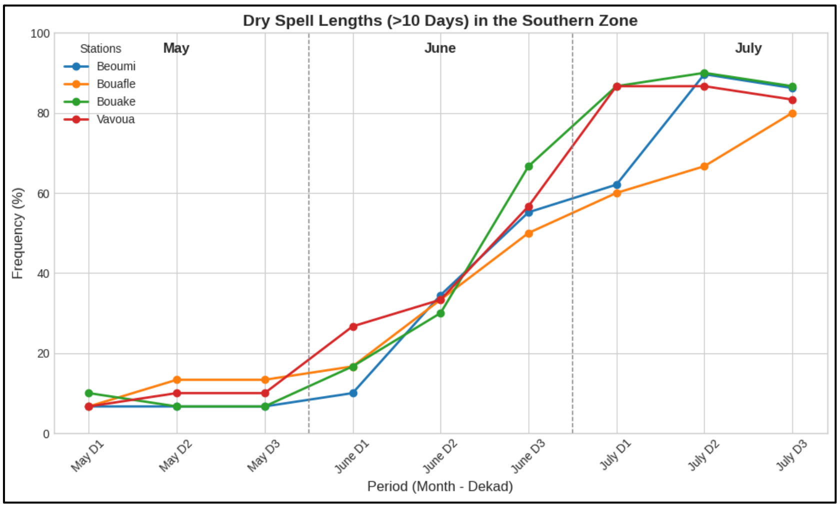

Figure 10 Probability of occurrence of dry spells longer than 10 days during the boll-opening stage (Southern zone)

4. Discussion

The interannual variability of crop yields largely depends on climatic factors [14]. The results of this study indicate that prolonged dry spells appear to create uncertainty in cotton (Gossypium hirsutum) development, corroborating findings from several authors [7, 15, 16]. Indeed, the analysis showed that the nine sowing dekads selected (from the first dekad of May to the third dekad of July) are exposed to the risk of dry spells longer than 10 days after sowing. Probabilities are below 35% for all sowing dekads in the Northern zone, exceed 60% from the third dekad of June in the Central zone, and approach 80% after the first dekad of June in the Southern zone. This increase in the frequency of dry spells limits seed germination and early plant growth, often forcing farmers to carry out one or more re-sowing operations. A direct consequence of cotton being shown during these dekads is poor leaf development due to water stress. These findings are consistent with those of Traoré *et al.* [17], who report that sowing outside the recommended windows reduces optimal growth of young cotton seedlings. Furthermore, Salack *et al*. [18] indicate that re-sowing leads to additional production costs in countries with limited seed capital.

Analysis of the probabilities of dry spell occurrence during the flowering phase showed that in the Northern zone, flowering coincides with probabilities of dry spells longer than 10 days exceeding 40% for sowings carried out in the third dekad of July. In the Central zone, sowing dekads associated with high probabilities of dry spells during flowering are the three dekads of May and the first two dekads of June, with probabilities ranging from 50% to 70%. In the Southern zone, probabilities of dry spells exceed 40% during flowering corresponding to sowings conducted between the first dekad of May and the second dekad of June, as well as in the third dekad of July. These identified dekads across the different zones expose the flowering phase to water stress. Since the fruiting period, which begins with flowering, is critical for the final crop yield, this exposure is particularly important. Indeed, Hennou *et al*. [19], Snowden *et al*. [20], and Singh *et al*. [21] conclude that any water stress induced by insufficient rainfall during flowering disrupts physiological processes, leading to flower drop and ultimately reducing yields.

Regarding the boll opening phase, the results show that in the Northern zone, sowings carried out between the first dekad of May and the second dekad of June are exposed to dry spell probabilities ranging from 0% to 40%. In the Central zone, low probabilities of dry spells are observed from the first dekad of May to the first dekad of June. In the Southern zone, probabilities of dry spells remain below 40% for sowings conducted between the first dekad of May and the second dekad of June. At the end of the cycle, prolonged dry spells are desirable. However, it is observed that sowings carried out in May (across all zones) and up to the first dekad of June (depending on the zone) are rather exposed to wet conditions. At this stage of the cycle, wet conditions could negatively affect the quality of the harvested cotton lint. Moreover, Yerima [22] indicates that rainfall is a major factor in cotton yellowing. This situation may result in the downgrading of cotton lint to a lower grade, thereby directly reducing market prices. Therefore, dryness should ideally be as consistent as possible. Indeed, several studies [23-25] suggest that a dry interval of 7 to 14 days represents an optimal threshold for accelerating boll opening without compromising fiber quality.

5. Conclusion

This study analyzed dry spells lasting more than 10 days throughout the cotton (Gossypium hirsutum) development cycle in Ivorian cotton production areas. Analysis of the probabilities of dry spell occurrence showed that, for all sowing dekad scenarios, cotton crops are exposed to climatic risks. This situation represents a limiting factor for cotton development in the Ivorian cotton areas. It is therefore essential to estimate the timing of these phases, which depend on sowing dates, to prevent the post-sowing and flowering periods from coinciding with dry spells, and to avoid boll opening coinciding with rainy periods. Accordingly, it is recommended to adjust sowing dates based on seasonal forecasts, use drought-tolerant varieties, and strengthen soil and water conservation practices in the most exposed areas. The implementation of an agro-climatic early warning system could also serve as an effective strategy to anticipate dry spells and mitigate their impacts on cotton production in Côte d'Ivoire.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

The authors declare no conflict of interest.

References

[1] Otchoumou K. F., Bachir S. M., Aké G. E., & Savané I. Variabilité climatique et productions de café et cacao en zone tropicale humide : Cas de la région de Daoukro (Centre-Est de la Côte d'Ivoire). International Journal of Innovation and Applied Studies. 2012; 1(2) :194–215.

[2] Yoroba F., Kouassi B. K., Diawara A., Yapo L. A., Kouadio K., Tiemoko D. T., Koné D. I., & Assamoi P. Evaluation of Rainfall and Temperature Conditions for a Perennial Crop in Tropical Wetland: A Case Study of Cocoa in Côte d'Ivoire. Advances in Meteorology. 2019; 10 p.

[3] Tra Bi Z. A., Brou Y. T., & Mahé G. Analyse par télédétection des conditions bioclimatiques de végétation dans la zone de contact forêt-savane de Côte d'Ivoire : cas du «V» Baoulé. XXVIIIe Colloque de l'Association Internationale de Climatologie, Liège. 2015.

[4] Dekoula C. S., Kouame B., N'Goran K. E., Ehounou J. N., Yao G. F., Kassin K. E., Kouakou J. B., N'Guessan A. E. B., et Soro N. Variabilité des descripteurs pluviométriques intrasaisonniers à impact agricole dans le bassin cotonnier de Côte d'Ivoire : cas des zones de Boundiali, Korhogo et Ouangolodougou. Journal of Applied Biosciences. 2018; 130:13199–13212. https://dx.doi.org/10.4314/jab.v130i1.7

[5] Koné I., Agyare W. A., Gaiser T., OwusuPrempeh N., Kouadio K.-K. H., Kouadio E. N., et al. Local cotton farmers' perceptions of climate change events and adaptations strategies in cotton basin of Côte d'Ivoire. Journal du Développement Durable. 2022; 15(3):108–124. DOI:10.5539/jsd.v15n3p108

[6] Chimimba E. G., Ngongondo C., Li C., et al. Characterisation of dry spells for agricultural applications in Malawi. SN Applied Sciences. 2023; 5:199. https://doi.org/10.1007/s42452-023-05413-9

[7] Sultan B., Bella-Medjo M., Quirion P., & Janicot S. Multi-scales and multi-sites analyses of the role of rainfall in cotton yields in West Africa. International Journal of Climatology. 2010; 30(1):58–71. https://doi.org/10.1002/joc.1872

[8] Njouenwet I., Vondou D. A., Fita Dassou E., Ayugi B. O., & Nouayou R. Assessment of agricultural drought during crop-growing season in the Sudano–Sahelian region of Cameroon. Natural Hazards. 2021; 106(1):561–577. https://doi.org/10.1007/s11069-020-04475-x

[9] Ducroquet H., Tillie P., & Louhichi K. L'agriculture de la Côte d'Ivoire à la loupe : État des lieux des filières de production végétales et animales et revue des politiques agricoles. Joint Research Centre, Seville. 2017; Rapport N° JRC107214, 242 p.

[10] Badaméli P. A. Changements climatiques au Togo et leurs impacts sur les activités agricoles. Thèse de Doctorat unique, Université de Lomé, Togo. 201 ; 236 p.

[11] CNTIG. Carte administrative de la Côte d'Ivoire, mars 2021. 2021. https://cartotheque-cntig.com/plusvendu/detailproduit?id=25

[12] Santé N., N'Go Y. A., Soro G. E., Meledje N. D. H., & Goula B. T. A. Characterization of meteorological droughts occurrences in Côte d'Ivoire: case of the Sassandra watershed. Climate. 2019; 7(4):60.

[13] Stern R. D., Rijks D., Dale I., & Knock J. INSTAT+ for Windows V3.036. Statistical Services Center, University of Reading: Reading. 2006.

[14] Fall C. M. N., Lavaysse C., Kerdiles H., Dramé M. S., Roudier P., & Gaye A. T. Performance of dry and wet spells combined with remote sensing indicators for crop yield prediction in Senegal. Climate Risk Management. 2021; 33:100331. https://doi.org/10.1016/j.crm.2021.100331

[15] Panthou G., Lebel T., Vischel T., Quantin G., Sane Y., Ba A., Ndiaye A., Diongue-Niang A., & Diopkane M. Rainfall intensification in tropical semi-arid regions: the Sahelian case. Environmental Research Letters. 2018; 13(6):064013. https://doi.org/10.1088/1748-9326/aac334

[16] Kheiri M., Kambouzia J., Rahimi-Moghaddam S., et al. Effects of agro-climatic indices on wheat yield in arid, semi-arid, and sub-humid regions of Iran. Regional Environmental Change. 2024; 24:10. https://doi.org/10.1007/s10113-023-02173-5

[17] Traoré B., Tonessia D. C., Tiho T., & Pohé J. Climate variability impact on cotton production in North Côte d'Ivoire. World Journal of Advanced Research and Reviews. 2025; 25(1):321–332. https://doi.org/10.30574/wjarr.2025.25.1.4052

[18] Salack S., Muller B., Gaye A. T., Hourdin F., & Cisse N. Analyses multi-échelles des pauses pluviométriques au Niger et au Sénégal. Sécheresse. 2012; 23:3–13. https://doi.org/10.1684/sec.2012.0335

[19] Hennou L., Zouzou M., Annerose D., Macauley H. R., & Nwalozie M. C. Réponses physiologiques et morphologiques au déficit hydrique de quatre variétés de cotonnier (Gossypium hirsutum L.). Revue CAMES - Série A. 1999; 1:87–98.

[20] Snowden M. C., Ritchie G. L., Simao F. R., & Bordovsky J. P. Timing of episodic drought can be critical in cotton. Agronomy Journal. 2014; 106(2):452–458. https://doi.org/10.2134/agronj2013.0325

[21] Singh K., Mishra S. K., Singh M., Singh K., & Brar A. S. Water footprint assessment of surface and subsurface drip fertigated cotton-wheat cropping system – A case study under semi-arid environments of Indian Punjab. Journal of Cleaner Production. 2022; 365:132735. https://doi.org/10.1016/j.jclepro.2022.132735

[22] Yerima B. Système de rémunération et amélioration de la qualité du coton au Bénin. Thèse de Doctorat, École Nationale Supérieure d'Agronomie de Montpellier, France. 2005; 271 p.

[23] Oosterhuis D. M. Yield response to environmental extremes in cotton. Special Reports – University of Arkansas Agricultural Experiment Station. 1999; 193:30–38.

[24] Ritchie G. L., Bednarz C. W., Jost P. H., & Brown S. M. Cotton growth and development. 2007. http://hdl.handle.net/10724/12192

[25] Traoré A., Sarr M., Loison R., Diouf L., & Ndiaye S. Contraintes et perspectives de la culture du coton en Afrique de l'Ouest dans un contexte de changement climatique : cas du Sénégal. Journal of Applied Biosciences. 2021; 166(1) :17168–17179. https://doi.org/10.35759/JABs.166.2